William Stallings
Data and Computer Communications
7th Edition

Chapter 2
Protocols and Architecture

Need For Protocol Architecture

- E.g. File transfer
  - —Source must activate comms. Path or inform network of destination
  - —Source must check destination is prepared to receive
  - —File transfer application on source must check destination file management system will accept and store file for his user
  - —May need file format translation
- Task broken into subtasks
- Implemented separately in layers in stack
- Functions needed in both systems
- Peer layers communicate

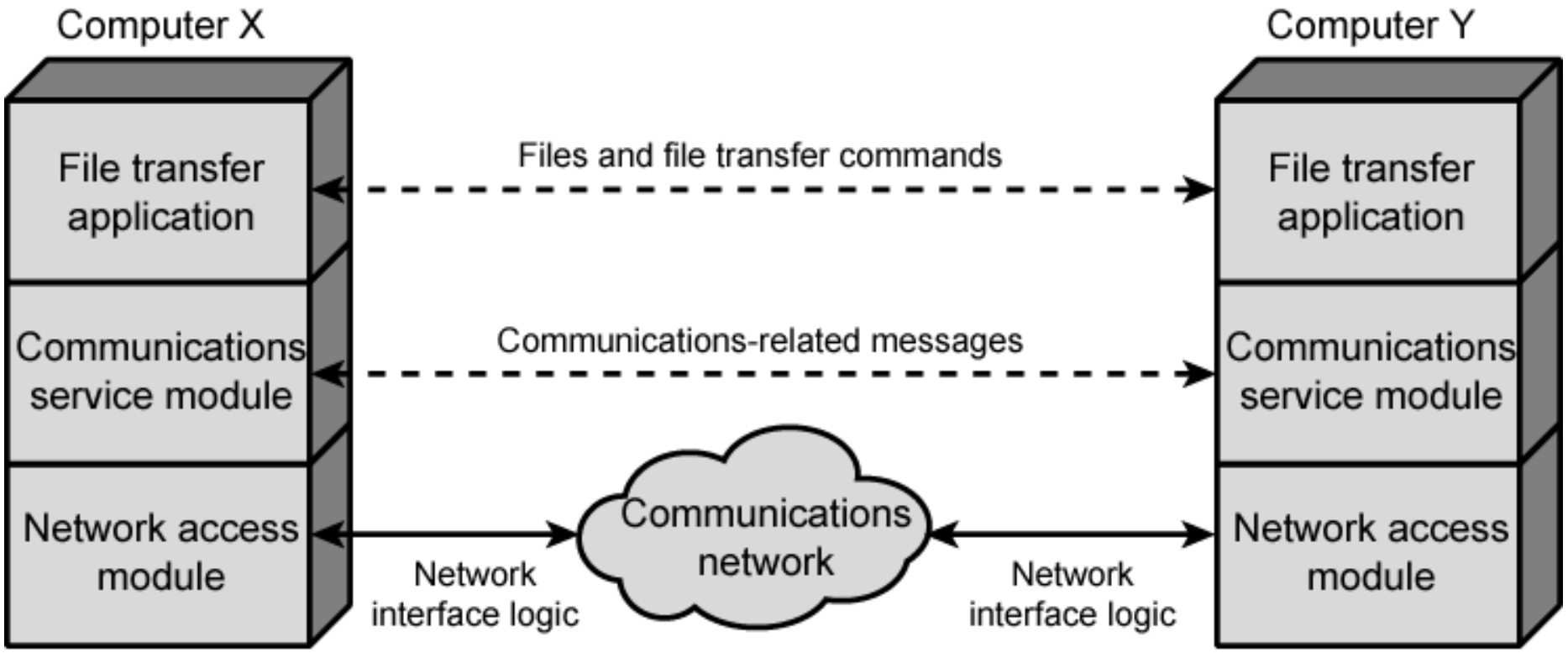
Key Elements of a Protocol

- Syntax
  - —Data formats
  - —Signal levels
- Semantics
  - —Control information
  - —Error handling
- Timing
  - —Speed matching
  - —Sequencing

Protocol Architecture

- Task of communication broken up into modules
- For example file transfer could use three modules
  - —File transfer application
  - —Communication service module
  - —Network access module

Simplified File Transfer Architecture



A Three Layer Model

- Network Access Layer
- Transport Layer
- Application Layer

Network Access Layer

- Exchange of data between the computer and the network
- Sending computer provides address of destination
- May invoke levels of service
- Dependent on type of network used (LAN, packet switched etc.)

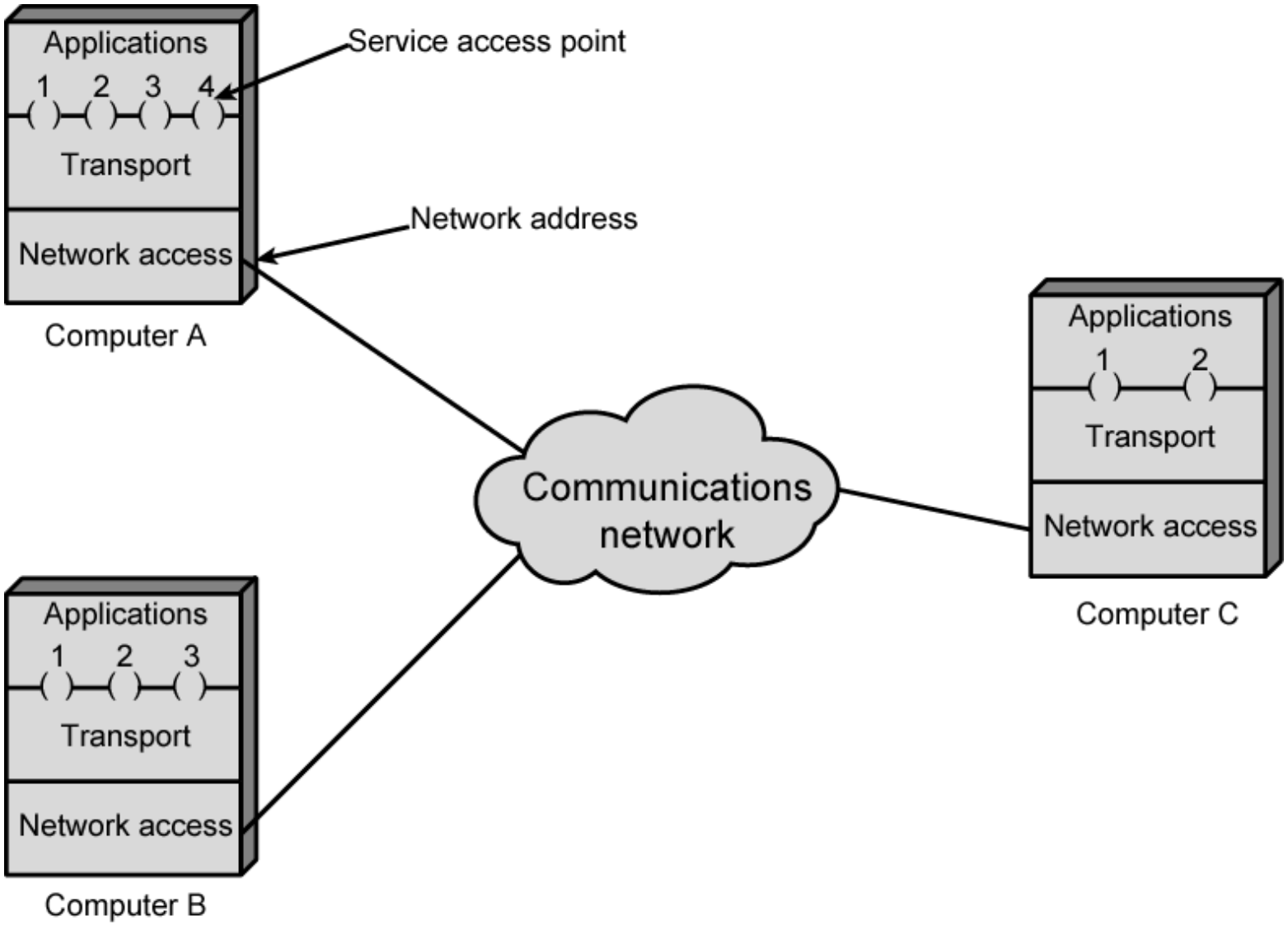
Transport Layer

- Reliable data exchange
- Independent of network being used
- Independent of application

Application Layer

- Support for different user applications
- e.g. e-mail, file transfer

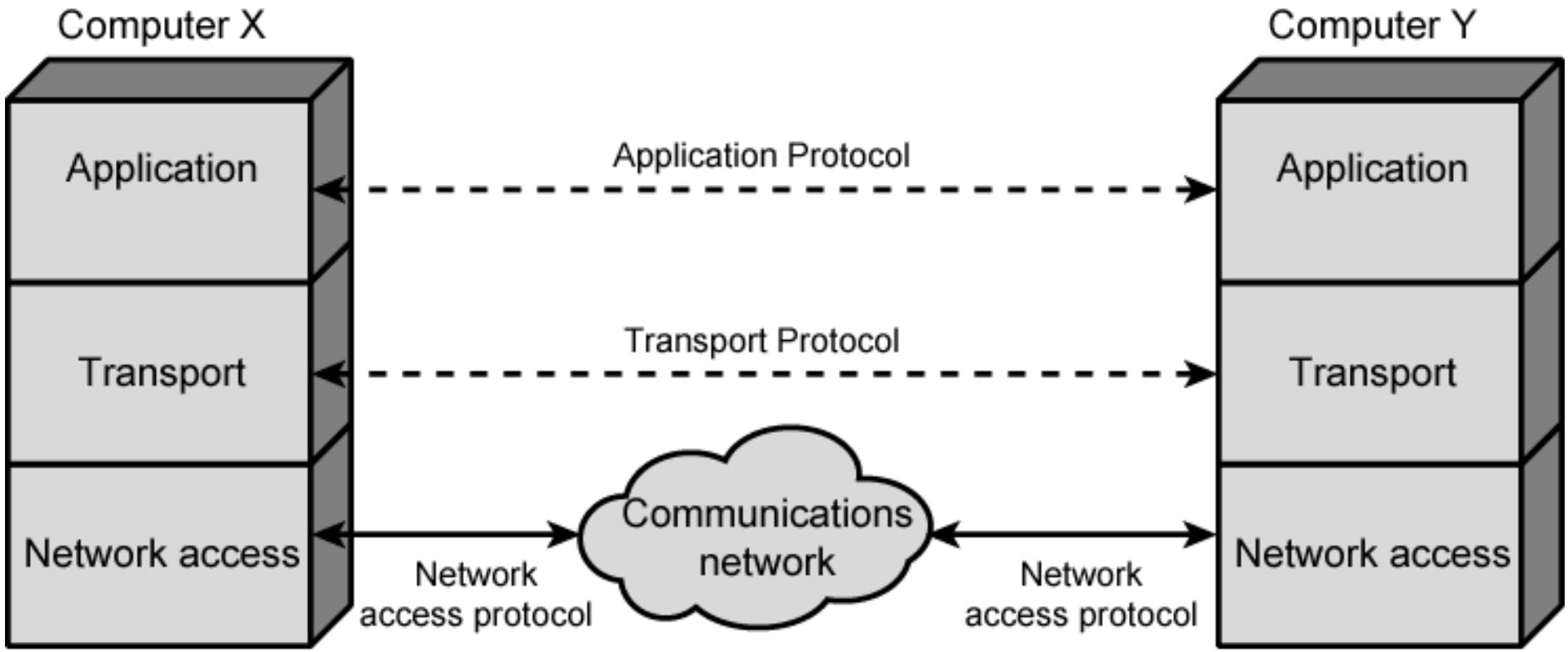
Protocol Architectures and Networks



Addressing Requirements

- Two levels of addressing required
- Each computer needs unique network address
- Each application on a (multi-tasking) computer needs a unique address within the computer
  - The service access point or SAP
  - The port on TCP/IP stacks

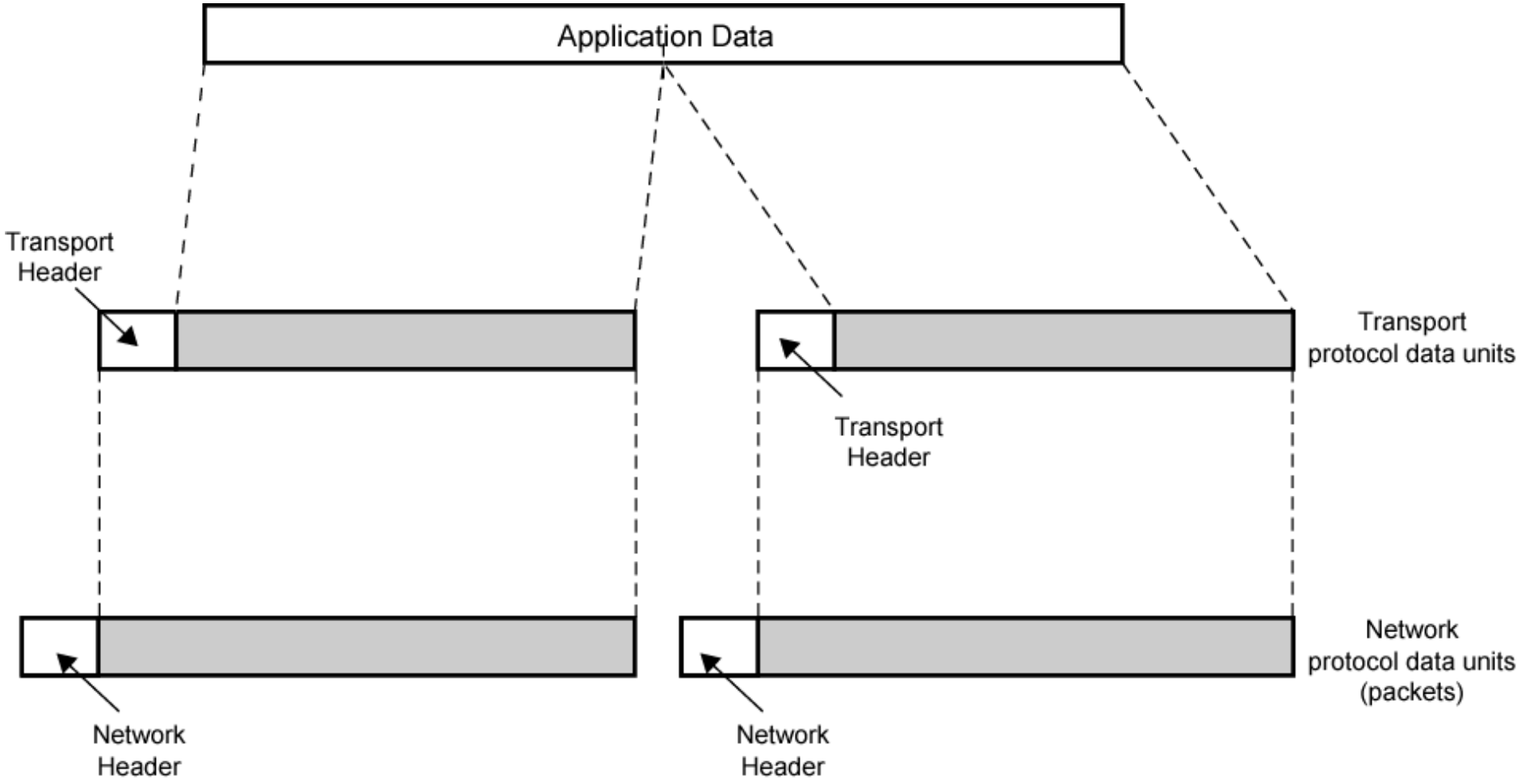
Protocols in Simplified Architecture



Protocol Data Units (PDU)

- At each layer, protocols are used to communicate
- Control information is added to user data at each layer
- Transport layer may fragment user data
- Each fragment has a transport header added
  - Destination SAP
  - Sequence number
  - Error detection code
- This gives a transport protocol data unit

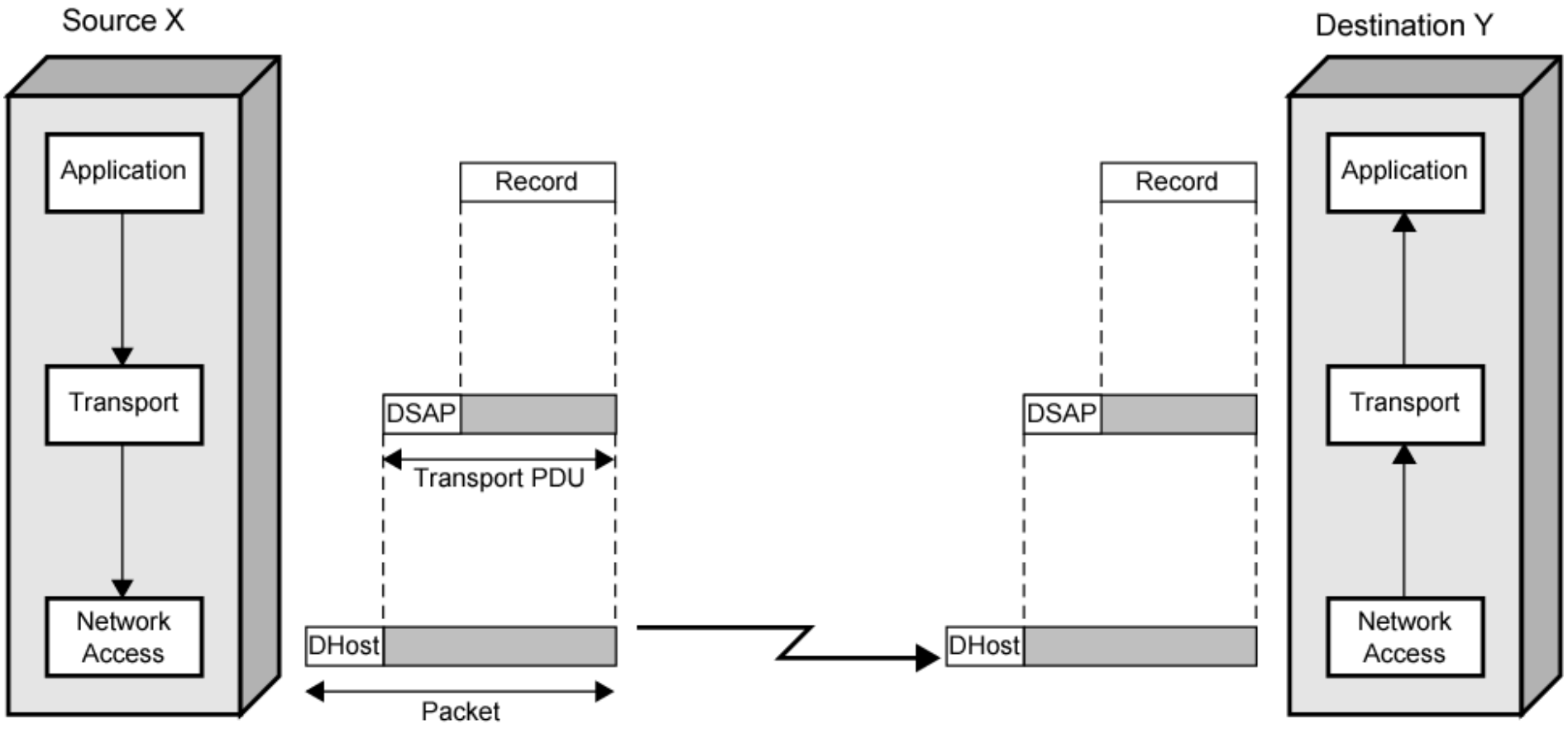
Protocol Data Units



Network PDU

- Adds network header
  - —network address for destination computer
  - —Facilities requests

Operation of a Protocol Architecture



DSAP = destination service access point
DHost = destination host

Standardized Protocol Architectures

- Required for devices to communicate
- Vendors have more marketable products
- Customers can insist on standards based equipment
- Two standards:
  - —OSI Reference model
    - Never lived up to early promises
  - —TCP/IP protocol suite
    - Most widely used
- Also: IBM Systems Network Architecture (SNA)

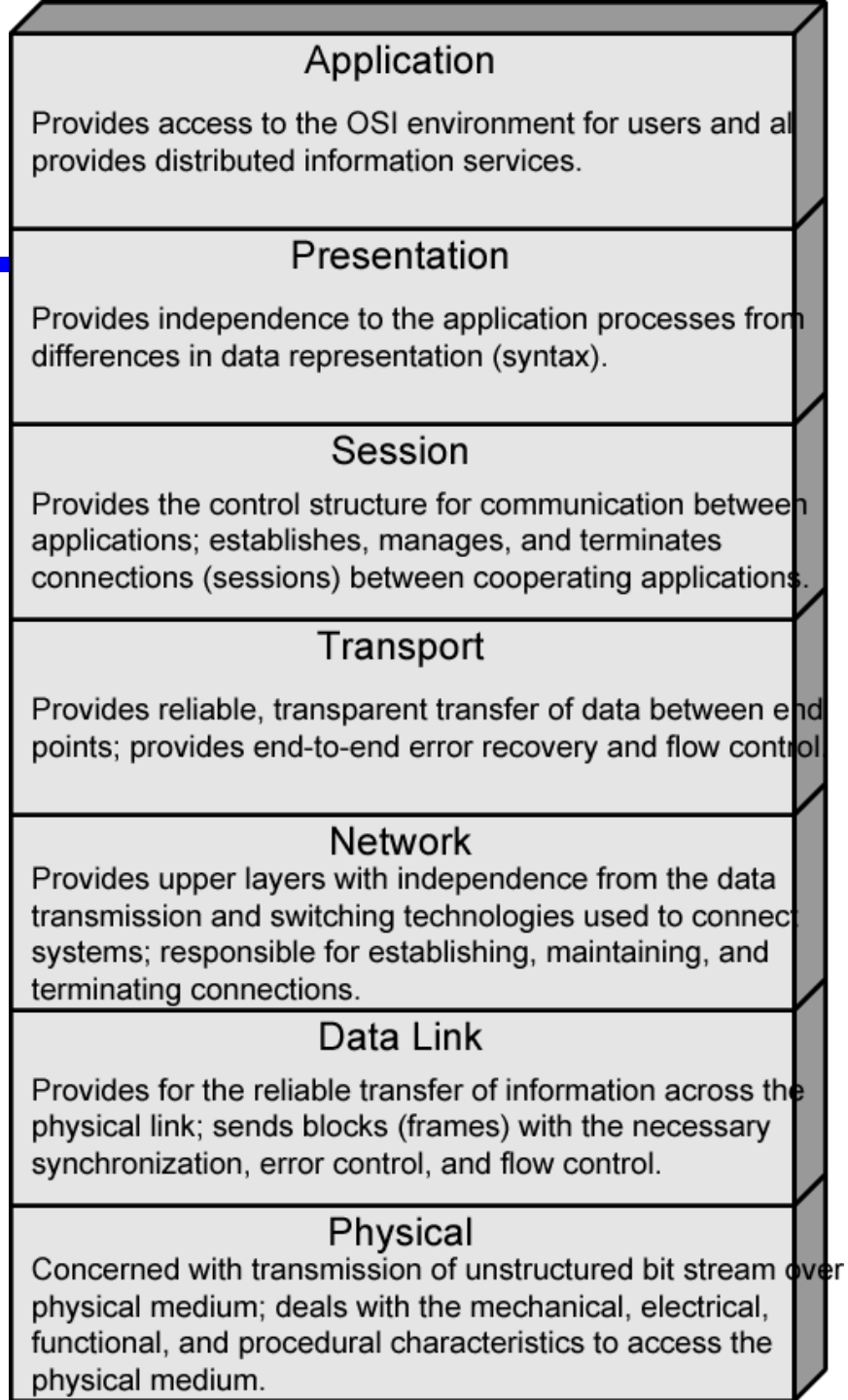
OSI

- Open Systems Interconnection
- Developed by the International Organization for Standardization (ISO)
- Seven layers
- A theoretical system delivered too late!
- TCP/IP is the de facto standard

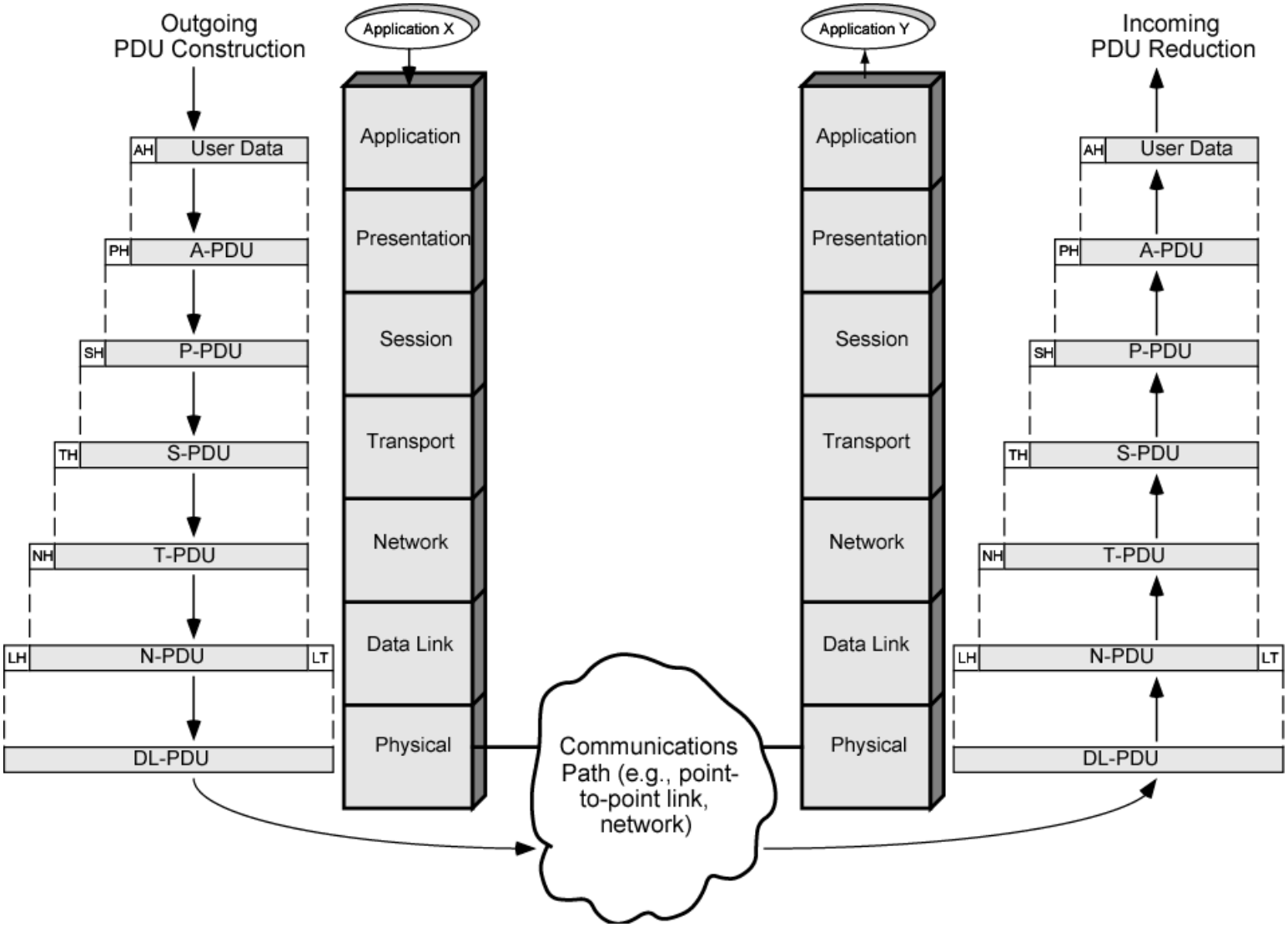
OSI - The Model

- A layer model
- Each layer performs a subset of the required communication functions
- Each layer relies on the next lower layer to perform more primitive functions
- Each layer provides services to the next higher layer
- Changes in one layer should not require changes in other layers

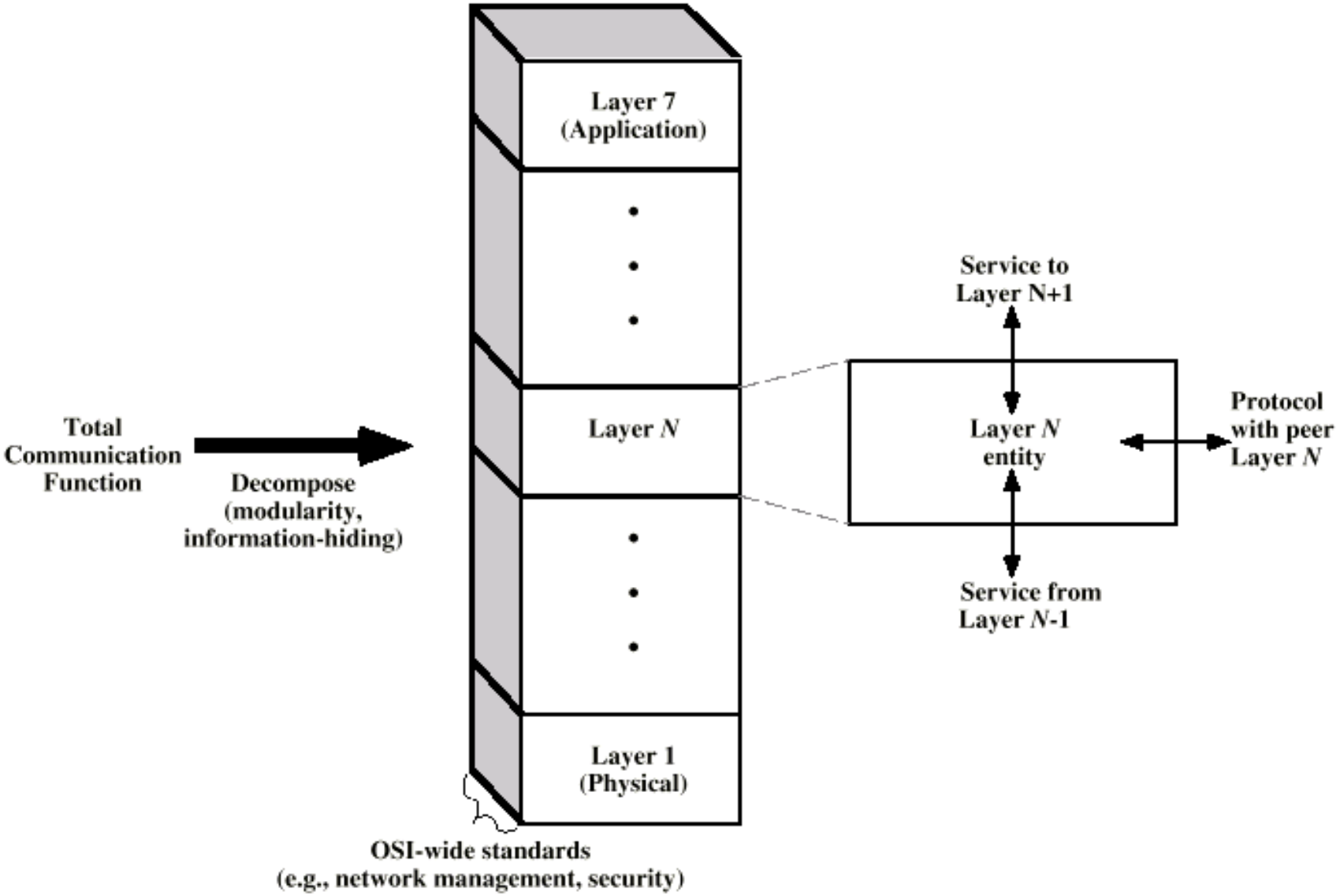
OSI Layers


Application
Provides access to the OSI environment for users and al
provides distributed information services.
Presentation
Provides independence to the application processes from
differences in data representation (syntax).
Session
Provides the control structure for communication between
applications; establishes, manages, and terminates
connections (sessions) between cooperating applications.
Transport
Provides reliable, transparent transfer of data between end
points; provides end-to-end error recovery and flow control
Network
Provides upper layers with independence from the data
transmission and switching technologies used to connect
systems; responsible for establishing, maintaining, and
terminating connections.
Data Link
Provides for the reliable transfer of information across the
physical link; sends blocks (frames) with the necessary
synchronization, error control, and flow control.
Physical
Concerned with transmission of unstructured bit stream over
physical medium; deals with the mechanical, electrical,
functional, and procedural characteristics to access the
physical medium.

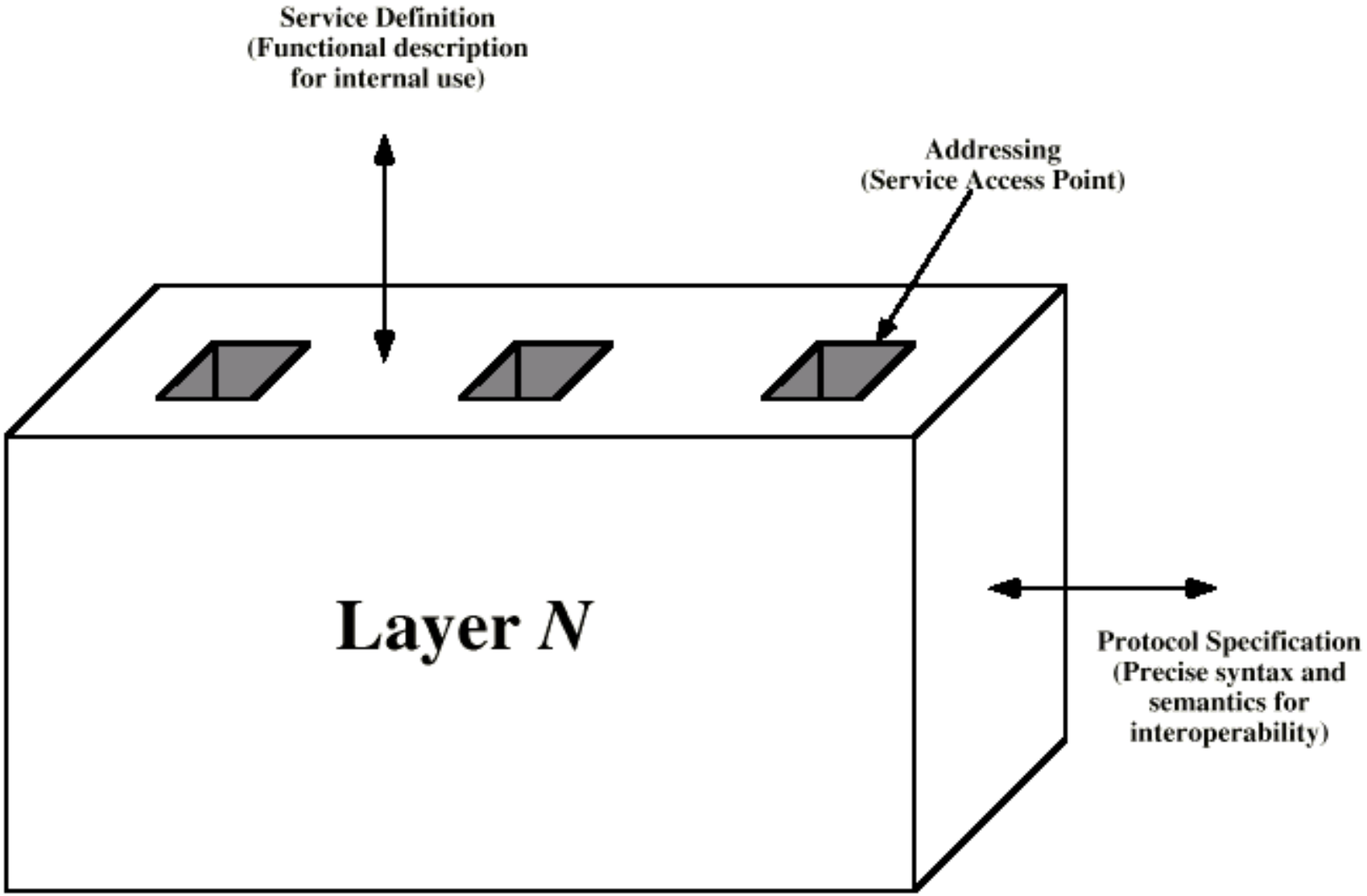
The OSI Environment



OSI as Framework for Standardization



Layer Specific Standards



Elements of Standardization

- Protocol specification
  - —Operates between the same layer on two systems
  - —May involve different operating system
  - —Protocol specification must be precise
    - Format of data units
    - Semantics of all fields
    - allowable sequence of PCUs
- Service definition
  - —Functional description of what is provided
- Addressing
  - —Referenced by SAPs

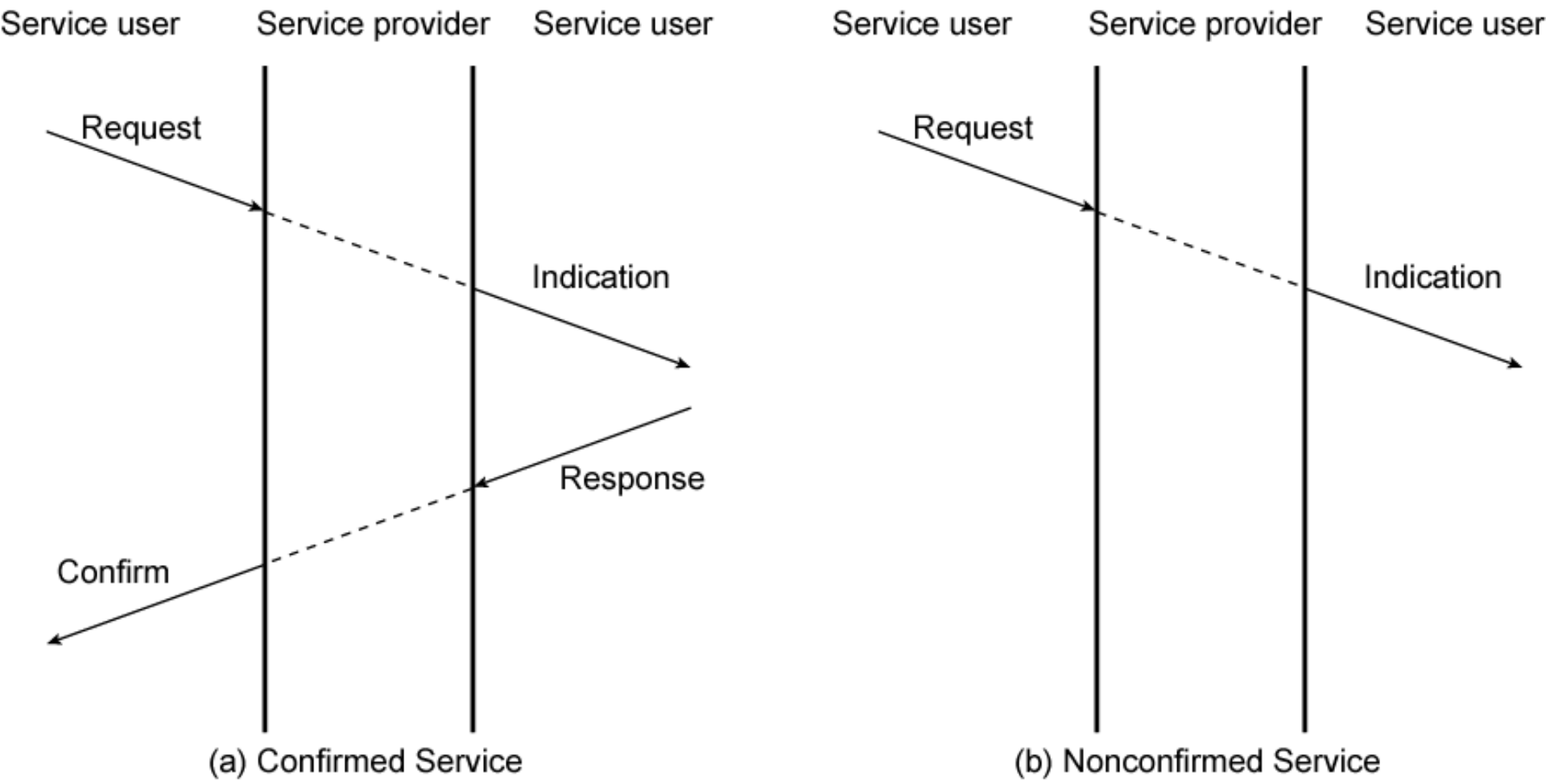
Service Primitives and Parameters

- Services between adjacent layers expressed in terms of primitives and parameters
- Primitives specify function to be performed
- Parameters pass data and control info

Primitive Types

REQUEST	A primitive issued by a service user to invoke some service and to pass the parameters needed to specify fully the requested service
INDICATION	A primitive issued by a service provider either to: indicate that a procedure has been invoked by the peer service user on the connection and to provide the associated parameters, or notify the service user of a provider-initiated action
RESPONSE	A primitive issued by a service user to acknowledge or complete some procedure previously invoked by an indication to that user
CONFIRM	A primitive issued by a service provider to acknowledge or complete some procedure previously invoked by a request by the service user

Timing Sequence for Service Primitives



OSI Layers (1)

- Physical
  - —Physical interface between devices
    - Mechanical
    - Electrical
    - Functional
    - Procedural
- Data Link
  - —Means of activating, maintaining and deactivating a reliable link
  - —Error detection and control
  - —Higher layers may assume error free transmission

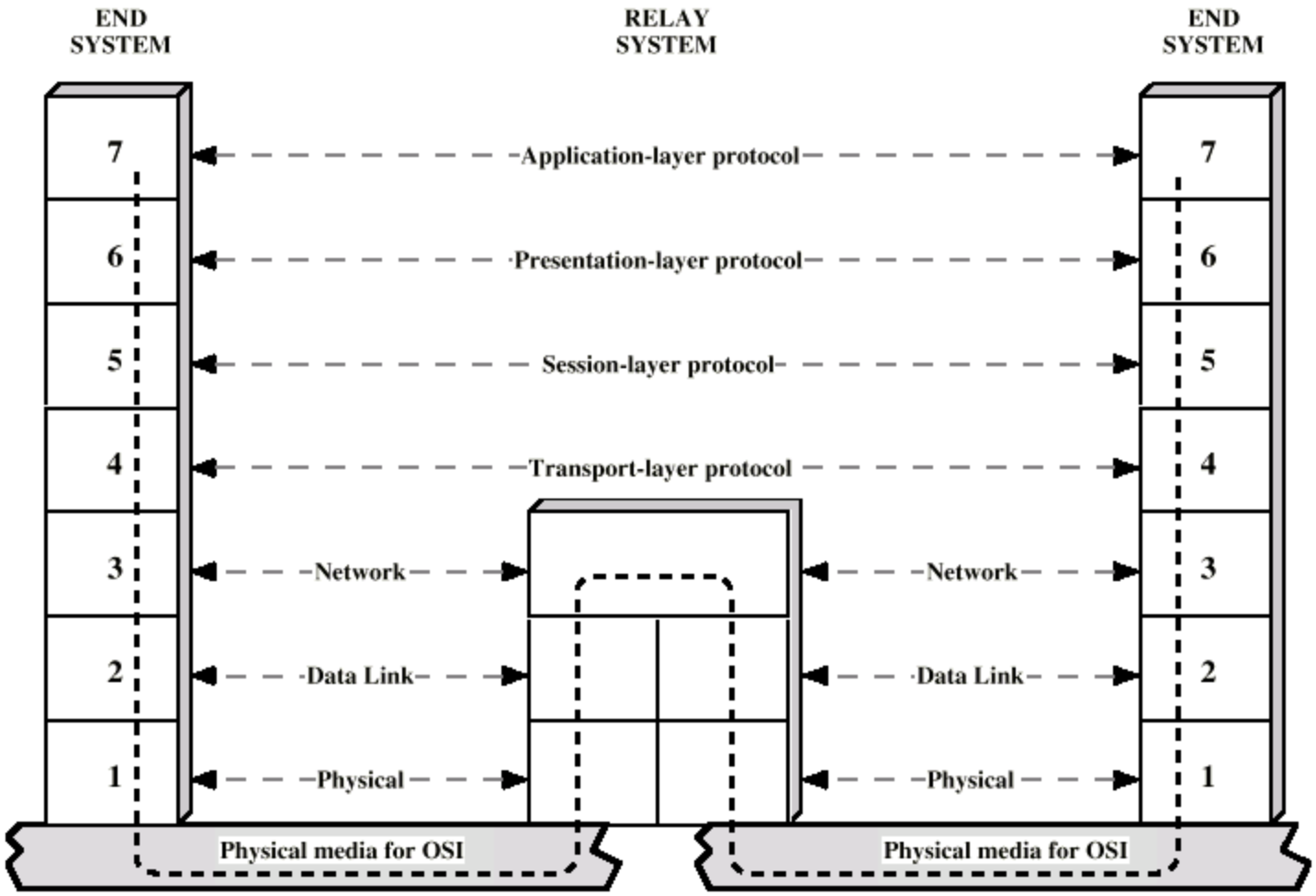
OSI Layers (2)

- Network
  - Transport of information
  - Higher layers do not need to know about underlying technology
  - Not needed on direct links
- Transport
  - Exchange of data between end systems
  - Error free
  - In sequence
  - No losses
  - No duplicates
  - Quality of service

OSI Layers (3)

- Session
  - —Control of dialogues between applications
  - —Dialogue discipline
  - —Grouping
  - —Recovery
- Presentation
  - —Data formats and coding
  - —Data compression
  - —Encryption
- Application
  - —Means for applications to access OSI environment

Use of a Relay



TCP/IP Protocol Architecture

- Developed by the US Defense Advanced Research Project Agency (DARPA) for its packet switched network (ARPANET)
- Used by the global Internet
- No official model but a working one.
  - —Application layer
  - —Host to host or transport layer
  - —Internet layer
  - —Network access layer
  - —Physical layer

Physical Layer

- Physical interface between data transmission device (e.g. computer) and transmission medium or network
- Characteristics of transmission medium
- Signal levels
- Data rates
- etc.

Network Access Layer

- Exchange of data between end system and network
- Destination address provision
- Invoking services like priority

Internet Layer (IP)

- Systems may be attached to different networks
- Routing functions across multiple networks
- Implemented in end systems and routers

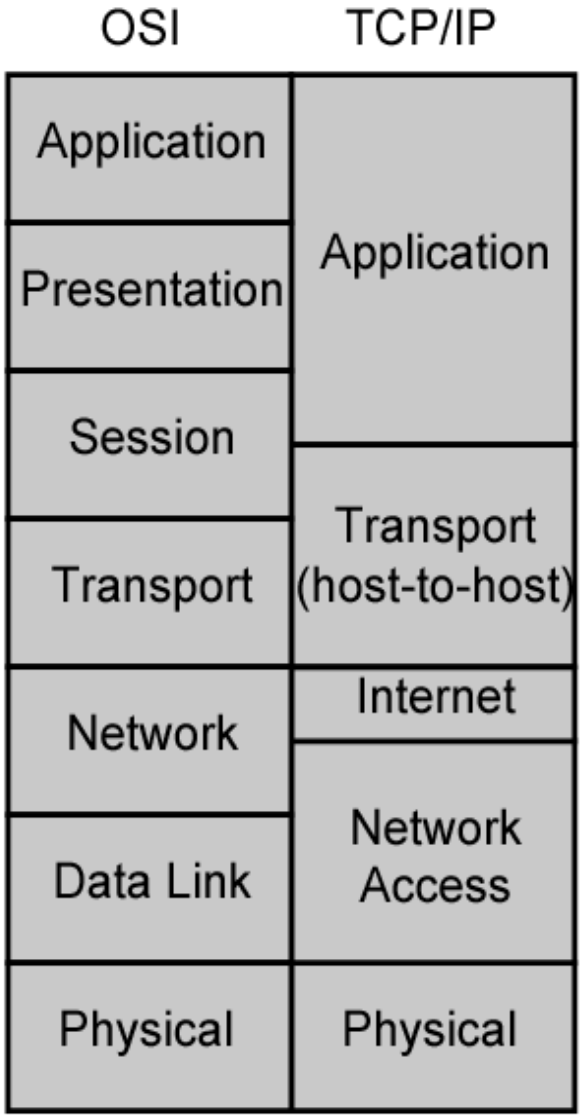
Transport Layer (TCP)

- Reliable delivery of data
- Ordering of delivery

Application Layer

- Support for user applications
- e.g. http, SMPT

OSI v TCP/IP


OSI
TCP/IP
Application
Presentation
Session
Transport
Network
Data Link
Physical
Application
Transport (host-to-host)
Internet
Network Access
Physical

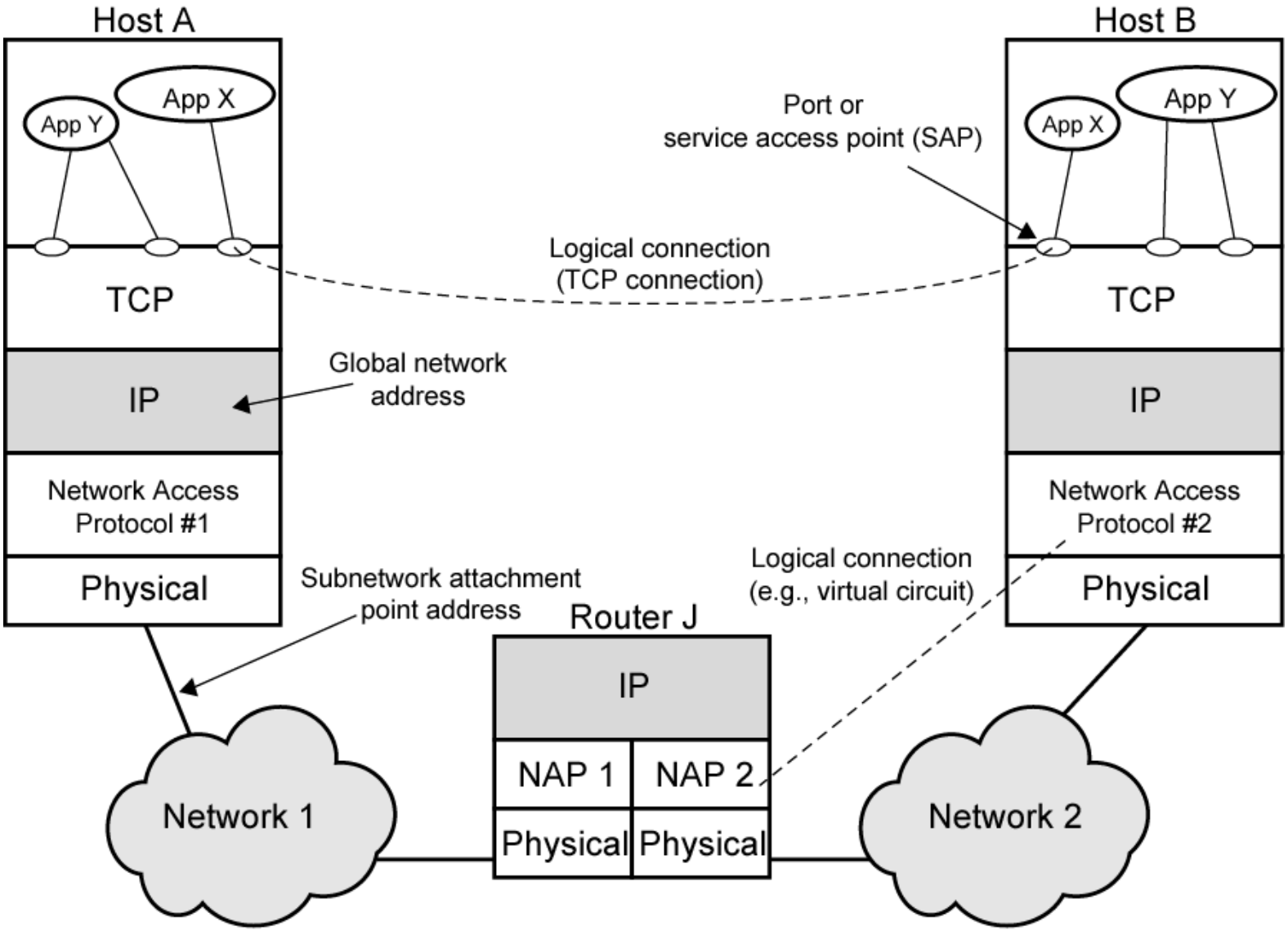
TCP

- Usual transport layer is Transmission Control Protocol
  - Reliable connection
- Connection
  - Temporary logical association between entities in different systems
- TCP PDU
  - Called TCP segment
  - Includes source and destination port (c.f. SAP)
    - Identify respective users (applications)
    - Connection refers to pair of ports
- TCP tracks segments between entities on each connection

UDP

- Alternative to TCP is User Datagram Protocol
- Not guaranteed delivery
- No preservation of sequence
- No protection against duplication
- Minimum overhead
- Adds port addressing to IP

TCP/IP Concepts



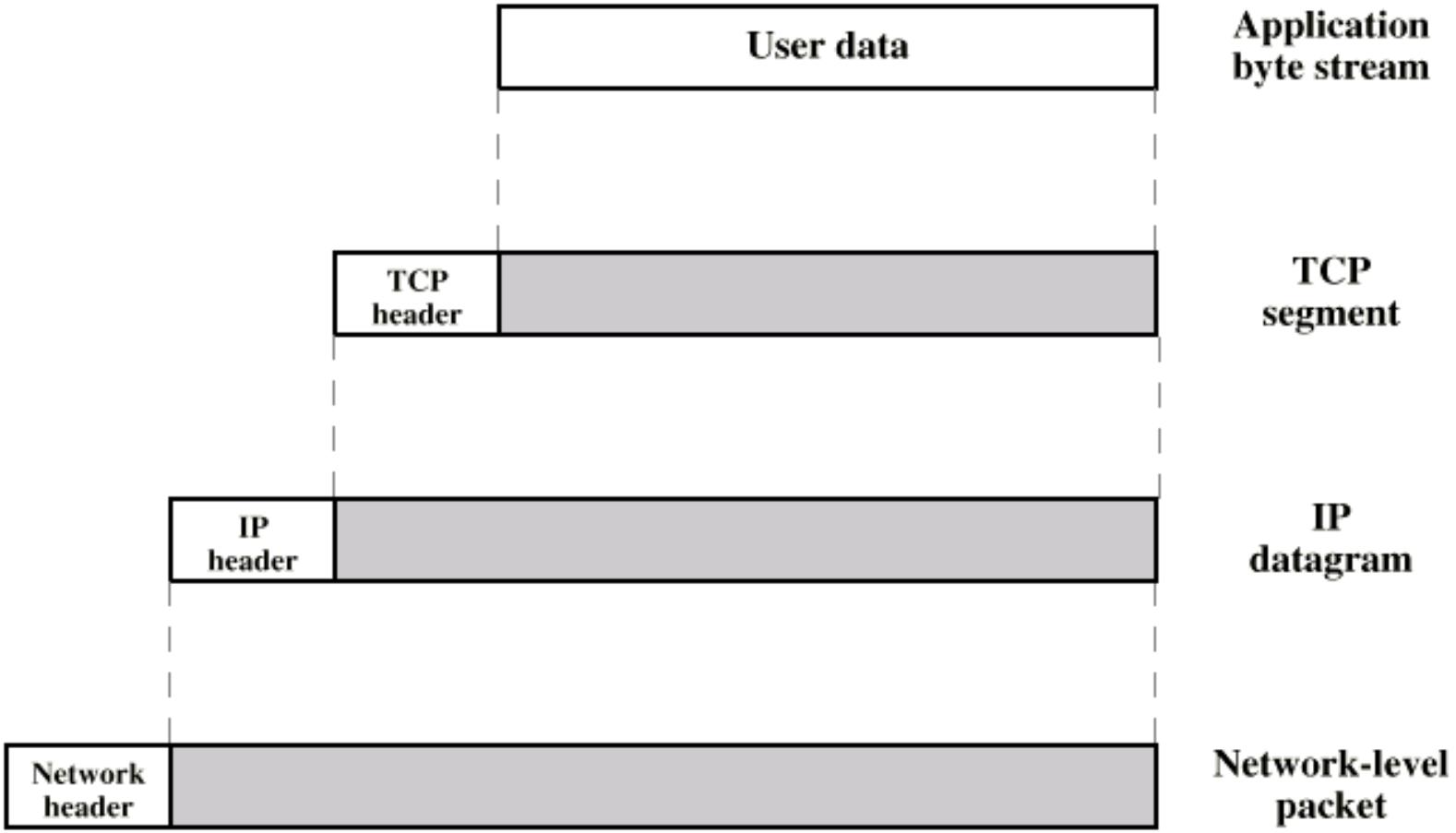
Addressing level

- Level in architecture at which entity is named
- Unique address for each end system (computer) and router
- Network level address
  - IP or internet address (TCP/IP)
  - Network service access point or NSAP (OSI)
- Process within the system
  - Port number (TCP/IP)
  - Service access point or SAP (OSI)

Trace of Simple Operation

- Process associated with port 1 in host A sends message to port 2 in host B
- Process at A hands down message to TCP to send to port 2
- TCP hands down to IP to send to host B
- IP hands down to network layer (e.g. Ethernet) to send to router J
- Generates a set of encapsulated PDUs

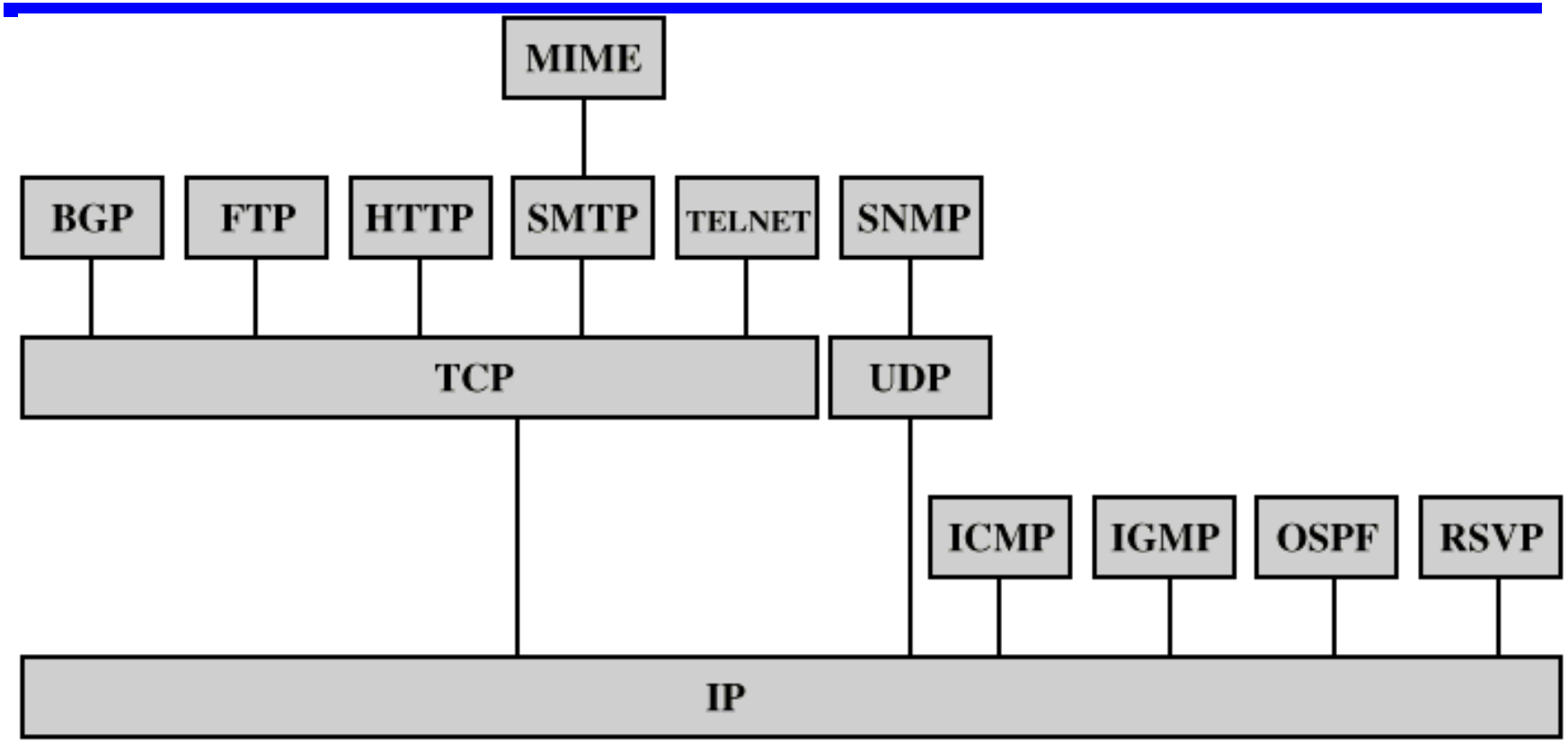
PDUs in TCP/IP



Example Header Information

- Destination port
- Sequence number
- Checksum

Some Protocols in TCP/IP Suite



BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multi-Purpose Internet Mail Extension
OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol

Required Reading

- Stallings chapter 2
- Comer,D. Internetworking with TCP/IP volume I
- Comer,D. and Stevens,D. Internetworking with TCP/IP volume II and volume III, Prentice Hall
- Halsall, F. Data Communications, Computer Networks and Open Systems, Addison Wesley
- RFCs